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TITLE: COMPACT MID-GRIP FASTENER

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COMPACT MID-GRIP FASTENER

Background of Invention

[0001] Well control is an important aspect of oil and gas exploration. When drilling a well in, for example, oil and gas exploration applications, devices must be put in place to prevent injury to personnel and equipment associated with drilling activities. One such well control device is known as a blowout preventer (BOP).

[0002] BOPs are generally used to seal a wellbore. For example, drilling wells in oil or gas exploration involves penetrating a variety of subsurface geologic structures, or “layers.” Generally, each layer is of a specific geologic composition such as, for example, shale, sandstone, limestone, etc. Each layer may contain trapped fluids or gas at different formation pressures, and the formation pressures generally increase with increasing depth. The pressure in the wellbore is typically adjusted to at least balance the formation pressure by, for example, increasing the density of drilling mud in the wellbore or increasing the pump pressure at the surface of the well.

[0003] There are occasions during drilling operations when a wellbore may penetrate a layer having a formation pressure that is substantially higher than the pressure maintained in the wellbore. When this occurs, the well is said to have “taken a kick.” The pressure increase associated with this “kick” is generally produced by an influx of formation fluids (which may be a liquid, a gas, or a combination of liquid and gas) into the wellbore. The relatively high pressure “kick” tends to propagate from a point of entry in the wellbore uphole (from a high pressure region to a low pressure region). If the “kick” is allowed to reach the surface, drilling fluid, well tools, and other drilling structures may be blown out of the wellbore. These blowouts often result in catastrophic destruction of the

drilling equipment (including, for example, the drilling rig) and a substantial risk of injury or death to rig personnel.

[0004] Because of the risks associated with blowouts, BOPs are typically installed at the surface or on the sea floor in deep water drilling arrangements so that “kicks” may be adequately controlled and circulated out of the system. BOPs may be activated to effectively seal a wellbore until active measures can be taken to control the kick.

[0005] Because of the extreme pressure that can be released during a kick, it is common practice to operate a “stack” of BOPs, where several BOPs are connected in a vertical relationship. For example, Figure 1 shows a BOP stack **100** with an upper BOP **104** stacked on top of a lower BOP **102**. Typically, the bottom end of the lower BOP **102** is coupled to the well head (not shown), and the top end of the upper BOP **104** is coupled to drilling or production equipment (not shown). It is also common to include more than two BOPs in an BOP stack.

[0006] Each BOP **102, 104** typically includes a center passage (shown in dashed lines) that passes vertically through the BOPs **102, 104**. It is these passages that well tools pass through during drilling and that the crude oil and gas passes through during production. It will be understood that each BOP **102, 104** may include rams, blocks, bonnets, and other BOP equipment that are not shown in Figure 1. Figure 1 is intended only to show the relative positions of BOPs in a BOP stack.

[0007] The BOPs **102, 104** are coupled together at the upper end of the lower BOP **102** and the lower end of the upper BOP **104**. Figures 2A–2C show several prior art methods for coupling two BOPs together.

[0008] Figure 2A shows a side view of a BOP stack **200** with a lower BOP **202** and an upper BOP **204** that are coupled together. The BOPs **202, 204** are coupled in a “flange-to-flange” arrangement. The lower BOP **202** has an upper flange **203**,

and the upper BOP 204 has a lower flange 205. The flanges 203, 205 are mated against each other so that the internal bores (shown in dashed lines) of each BOP 202, 204 are lined up.

[0009] Studs 207 are passed through both the flange 203 on the lower BOP 202 and the flange 205 on the upper BOP 204. A nut 209 is used on each end of each stud 207 to retain the flanges 203, 205 in place and couple the BOPs 202, 204 together. Figure 2A shows only two studs 207, but a typical BOP stack may use twelve studs arranged in a bolt pattern around the flanges 203, 205. A larger BOP will generally require more studs, and there is no limit to the number used.

[0010] Figure 2B shows a cross section of a BOP stack 210 in a “flange-to-stud” arrangement. The upper BOP 214 includes a lower flange 215 that is mated against a sealing surface 216 on the top of the lower BOP 212. The lower BOP 212 does not include a flange. Studs 217 are fixed in the lower BOP 212 about the center passage (shown in dashed lines), and the studs 217 pass through the flange 215 of the upper BOP 214. Nuts 219 retain the flange 215 on the upper BOP 214 against the sealing surface 216 on the lower BOP 212.

[0011] Figure 2C shows a cross section of a BOP stack 220 that includes two BOPs 222, 224 connected using a “stud-to-stud” arrangement with a spool 231. The spool 231 includes an upper flange 232, a lower flange 233, and a central passage (shown in dashed lines) that is aligned with the central passages of the BOPs 222, 224. Each of the BOPs 222, 224 includes studs 227 that are fixed about the central passage. The spool is aligned with the studs 227 on each BOP 222, 224, and the studs pass through the flanges 232, 233 of the spool 231. Nuts 229 retain the spool in place to connect the BOPs 222, 224.

[0012] Each of these connection methods requires the use of at least one flange, which adds to the height of the BOP stack. Because of the limited space near the well head, it is desirable to reduce the BOP stack height as much as possible.

Summary of Invention

- [0013] In some embodiments, the invention relates to a fastener for coupling blowout preventers in a stack. The fastener includes an elongated shaft having a first and a second end, with a head disposed proximate the first end of the shaft. The head may be adapted to be retained in a recess in a connecting face of a first blowout preventer. The second end of the elongated shaft may be coupled to a second blowout preventer. In some embodiments, the second end of the elongated shaft is in threaded engagement with the second blowout preventer.
- [0014] In other embodiments, the invention relates to a coupled blowout preventer stack comprising a first blowout preventer having a plurality of recesses in a connecting face and a second blowout preventer in a vertical arrangement with the first blowout preventer. The blowout preventer stack also includes a plurality of fasteners each having an elongated shaft with a first end and a second end, the plurality of fasteners each comprising a head proximate the first end of the elongated shaft. The heads are disposed in the plurality of recesses in the first blowout preventer, and the second ends of the plurality of fasteners are coupled to the second blowout preventer.
- [0015] In some embodiments, the invention relates to a method for coupling two blowout preventers in a blowout preventer stack. The method includes coupling a first end of a plurality of fasteners to a first blowout preventer and positioning a second blowout in a vertical arrangement with the first blowout preventer so that a head on a second end of each of the plurality of fasteners is received in one of a plurality of recesses in a connecting face of the second blowout preventer. The method may also include coupling a plurality of retaining collars to the second blowout preventer so that the heads of the plurality of fasteners are retained in the plurality of recesses in the second blowout preventer and tightening the connection.

- [0016] In some embodiments the invention relates to a fastener for coupling blowout preventers in a stack comprising a first member having a first head adapted to be retained in a recess in a first blowout preventer, and a second member adapted to be coupled to a second blowout preventer. The first member and the second member are configured to be coupled to each other.
- [0017] Other aspects and advantages of the invention will be apparent from the following description and the appended claims.

Brief Description of Drawings

- [0018] Figure 1 shows a cross section of a blowout preventer stack.
- [0019] Figure 2A shows a side view of a prior art flange-to-flange connection.
- [0020] Figure 2B shows a side view of a prior art flange-to-stud connection.
- [0021] Figure 2C shows a side view of a prior art stud-to-stud connection with a spool.
- [0022] Figure 3 shows a cross section of a blowout preventer stack that is connected with one embodiment of a fastener in accordance with the present invention.
- [0023] Figure 4A shows a cross section of a fastener in accordance with one embodiment of the invention.
- [0024] Figure 4B shows a cross section of one embodiment of a fastener in accordance with the invention coupled to one blowout preventer before a second blowout preventer is vertically arranged with the first blowout preventer.
- [0025] Figure 4C shows a cross section of one embodiment of a fastener in accordance with the invention coupled to one blowout preventer with a second blowout preventer in a vertical arrangement with the first blowout preventer.

- [0026] Figure 4D shows a cross section of a fastener in accordance with one embodiment of the invention.
- [0027] Figure 5A shows a perspective view of a retaining collar in accordance with one embodiment of the invention.
- [0028] Figure 5B shows a perspective view of a retaining collar in accordance with one embodiment the invention.
- [0029] Figure 6A shows a cross section of a head in accordance with one embodiment of the invention.
- [0030] Figure 6B shows a cross section of a head in accordance with one embodiment of the invention.
- [0031] Figure 7A shows a side view of a blowout preventer stack in accordance with one embodiment of the invention.
- [0032] Figure 7B shows a cross section of a blowout preventer stack and a fastener in accordance with one embodiment of the invention.
- [0033] Figure 8A shows a cross section of a blowout preventer stack and a fastener in accordance with one embodiment of the invention.
- [0034] Figure 8B shows a cross section of a blowout preventer stack and a fastener in accordance with one embodiment of the invention.

Detailed Description

- [0035] In certain embodiments, the invention relates to a fastener for coupling two blowout preventers (“BOP”) together in a BOP stack. In some embodiments, a fastener may include a grip section that enables the fastener to be gripped and rotated. A grip section may be located on the fastener so that the grip section may be accessed in the space between the BOP’s. In some other embodiments, a retaining collar on a BOP includes a bolt section that can be gripped and rotated.

The invention is referred to as a “mid-grip” fastener because instead of gripping and rotating a bolt or nut behind a flange, a fastener or retaining collar according to the invention may be gripped in the space between the two BOP’s. Certain embodiments of the invention will now be described with reference to the attached figures.

[0036] Figure 3 shows a cross section of one embodiment of a fastener in accordance with the invention. A lower BOP 302 and an upper BOP 304 are coupled together in a BOP stack 300. Central passages in each BOP 302, 304 (passages shown generally at 306) are aligned. The BOPs 302, 304 are coupled using multiple fasteners (e.g., the one shown at 310). The cross section of Figure 3 shows only two fasteners in the “bolt pattern,” but, as is known in the art, bolt patterns may include any number of bolts. In this case, the fasteners take the place of the bolts in the bolt pattern.

[0037] The fastener 310 includes a head 311 that is disposed inside a recess 308 in the upper BOP 304. The head 311 is retained in the recess 308 by a retaining collar 317 positioned in the recess 308. The opposite end of the fastener 310 includes a threaded section 313 that is in a threaded engagement with the lower BOP 302. The recess 308 is located in the connecting face of the upper BOP 304 that is being coupled to the lower BOP 302. A “connecting” face is the face of the BOP that faces the another BOP to which the first BOP is coupled.

[0038] The fastener 310 includes a grip section 315 that may be gripped by a wrench or other tool (not shown) that can apply torque to the fastener 310. As the fastener 310 is rotated in one direction, the threaded section 313 further engages the lower BOP 302, and the head 311 pulls the upper BOP 304 into engagement with the lower BOP 302. The grip section 315 is located on the fastener 310 so that it can be accessed in the space between the BOPs 302, 304.

- [0039] Figure 4A shows a close up of a cross section of one embodiment of a fastener 410 in accordance with the invention. A lower BOP 402 and an upper BOP 404 are coupled together in a BOP stack 400 by a fastener 410. The fastener 410 has an elongated shaft 416 with a head 411 at one end and a threaded section 413 at the other end. The head 411 is retained in a recess 406 of the upper BOP 404 and the threaded section 413 that is engaged with the lower BOP 402.
- [0040] The head 411 of the fastener 410 is retained in the recess 406 of the upper BOP 404 by a retaining collar 417. In the embodiment shown, the head 411 is an integral part of the shaft 416. In other embodiments, the head 411 comprises a separate piece that may be coupled to the shaft 416, for example, by threads, as would be done with a nut. One embodiment of a fastener that includes a nut is described later with reference to Figure 7B. Those having ordinary skill in the art will be able to devise other methods of coupling a head portion to a fastener without departing from the scope of the invention.
- [0041] In the embodiment shown, the retaining collar 417 is an annular retaining collar that includes a center passage through which the elongated shaft 416 may pass. The retaining collar 417 also includes a threaded outer section that can be coupled to corresponding threads in the recess 406 of the upper BOP 404. This enables the head 411 to be inserted into the recess 406 and then retained by threading the retaining collar 417 into the recess 406.
- [0042] In the embodiment shown, the threaded section 413 of the fastener 410 is coupled to the lower BOP 402 by a threaded engagement. It is also within the scope of the invention for a fastener to include two head sections without a threaded section. Certain of these embodiments are described later with reference to Figures 7A and 7B.
- [0043] In the embodiment shown in Figure 4A, the fastener 410 includes a grip section 415 that enables a wrench or other tool (not shown) to grip the fastener

410 and cause it to rotate. In the embodiment shown, the grip section **415** comprises a hexagonal-shaped surface that enables a wrench to grip the fastener **410**. The grip section **415** is located on elongated shaft **416** so that it can be accessed in the space between the BOPs **402, 404**. Other shapes and grip types may be used without departing from the scope of the invention. For example, the grip section may comprise a square-shaped surface or an octagonal-shaped surface. Those having ordinary skill in the art will be able to devise other grip sections that do not depart from the scope of the invention. It is also noted that the details of the grip section, while they would not generally appear in this cross section, are shown in the Figures for illustrative purposes.

[0044] Once the upper BOP **404** is in position and the retaining collar **417** has been installed to retain the head **411** of the fastener **410** in the recess **406**, the fastener **410** may be rotated to “tighten” or “loosen” the engagement between the upper BOP **404** and the lower BOP **402**. Figure 4A shows how a fastener **410** may be used to “tighten” or “loosen” the engagement between two BOPs **402, 404** in a BOP stack. Rotation of the fastener **410** may be in either direction, where one direction will tighten the connection, and the opposite directed will loosen the connection.

[0045] “Tighten,” as used herein, means to increase the connection force between the two BOPs. This is accomplished by rotating the fastener **410** so that the threaded section **413** will further engage the lower BOP **402**. The fastener **410** will be driven further into the lower BOP **402**, and the head **411** will be pulled downward. Because the head **411** is retained in the recess **406** by a retaining collar **417**, the downward movement of the head **411** will pull the upper BOP **404** toward the lower BOP **402**, thereby increasing the forces of the engagement of the BOPs **402, 404**.

[0046] “Loosen,” as used herein, means to decrease the connection force between the two BOPs **402, 404**. This is accomplished by rotating the fastener **410** in the other direction, so that engagement of the threaded section **413** causes the fastener **410** to be driven out of the lower BOP **402**. This will move the head **411** upwardly and release some of the forces between the BOPs **402, 404**.

[0047] The threaded engagement between the threaded section **413** of the fastener **410** and the lower BOP **402** is designed to support the forces between two BOP’s in a BOP stack. In some embodiments, such as the ones shown in Figure 4A, the invention includes a threaded engagement because of the strength of this type of connection in supporting compressive and tensile loads, and because a threaded connection enables the connection forces to be controlled and adjusted after an upper BOP is installed in the BOP stack. Other types of connections between a fastener and a BOP may be used without departing from the scope of the invention.

[0048] Figures 4B and 4C show how a BOP stack may be assembled using one embodiment of the invention. Figure 4B shows a cross section of a lower BOP **402** with a fastener **410** coupled to the lower BOP **402**. In some embodiments, such as the one shown in Figure 4B, the fastener **410** is in threaded engagement with the lower BOP **402**. The head **411** of the fastener **410** is positioned to be received in a recess (not shown) in an upper BOP (not shown). A retaining collar **417** is disposed around the elongated shaft **416** of the fastener **410**, but the retaining collar is not yet otherwise coupled any part of a BOP.

[0049] Figure 4C is similar to Figure 4B, but Figure 4C shows an upper BOP **404** that has been positioned above the lower BOP **402** in a BOP stack **400**. The head **411** of the fastener **410** is received or positioned within a recess **406** in the upper BOP **404**. In order to retain the head **411** of the fastener **410** in the recess **406** of the upper BOP **404**, the retaining collar **417** may be coupled to the upper BOP

404, as shown in Figure 4A. In some embodiments, the retaining collar **417** is coupled to the upper BOP **404** by a threaded engagement.

[0050] The method of installing the retaining collar **417** is not intended to limit the invention. For example, a retaining collar in accordance with the invention may include a handle to facilitate its installation. In the embodiment shown in Figures 4A–4C, the engagement of the retaining collar **417** does not increase the connection forces between the BOPs **402, 404**; thus, a high torque is not required to install the retaining collar **417**.

[0051] Once the upper BOP **404** is positioned above the lower BOP **402** and the retaining collar **417** is in place, the fastener **410** may be rotated to adjust the load between the upper BOP **404** and the lower BOP **402**. As discussed above, with reference to Figure 4A, the grip section **415** enables the fastener **410** to be rotated by a wrench or other tool (not shown).

[0052] Figure 4D shows another embodiment of a fastener **460** and a retaining collar **467** in accordance with the invention. The fastener **460** does not include a grip section. Instead, the retaining collar **467** includes a projection **468** that may be gripped by a wrench or other tool (not shown). In some embodiments, the projection **468** is a bolt section that has a hexagonal outside edge similar to that of a bolt head or a nut. The projection projects into the space between the BOPs, **452, 454** so that, similar to a grip section (**415** in figure 4A) described above, it can be accessed in that space.

[0053] In this embodiment, the retaining collar **467** engages the head **461** of the fastener **460** to pull the fastener **460**, which is in threaded connection with the lower BOP **452**, further into the recess **456**. In doing so, the connection forces may be increased. The load between the upper BOP **454** and the lower BOP **452** may be controlled by rotation of the retaining collar **467**. The connection may be tightened or loosened, depending on the direction of rotation.

[0054] Figures 5A and 5B show two embodiments of retaining collars in accordance with the invention. These two embodiments are provided only as examples; the invention is not intended to be limited to these embodiments.

[0055] Figure 5A shows one embodiment of a threaded retaining collar 501. The retaining collar 501 includes a center passage 503, through which a shaft (*e.g.*, 416 in Figure 4A) of a fastener may pass. The outside edge 505 of the retaining collar 501 includes threads 506 that are adapted to engage with corresponding threads (not shown) on a BOP (not shown) to retain the head of a fastener (not shown) in a recess of the BOP (not shown). This embodiment of a retaining collar is also shown in Figure 4A.

[0056] Figure 5B shows a perspective view of another embodiment of a retaining collar 511 in accordance with the invention, such as the one shown in Figure 4D. The retaining collar 511 includes a central passage 513 and threads 516 formed on an outer edge 515 of the retaining collar 511. The retaining collar 511 also includes a projection 518 that projects from the retaining collar 511. In some embodiments, such as the one shown in Figure 5B, the projection 518 is a bolt section that has a hexagonal outside edge that is shaped like a bolt head or nut. The bolt projection 518 is adapted to be gripped by a wrench or other tool so that the retaining collar 511 may be rotated while it is coupled to a BOP (not shown). This enables the connection between two BOPs (not shown) to be tightened or loosened, depending on the direction of rotation.

[0057] Figure 6A is a cross section of the head 611 of a fastener in accordance with one embodiment of the invention. The head 611 includes a groove 631, and a head ring 633 positioned in the groove 631. The head ring 633 is a circular ring that surrounds the top of the elongated shaft 615. The head ring 633 creates the effect of having a head with a larger diameter than the nominal diameter of the elongated shaft 615.

[0058] A retaining ring 635 is installed in a groove 637 in the recess 616 in the BOP 604. The retaining ring 635 may be installed in the groove 637 of the recess 616 after the head 611 is positioned in the recess 616. The retaining ring 635 has an inner diameter that is smaller than the outer diameter of the head ring 633. Thus, when installed, the retaining ring 635 retains the head 611 in the recess 616 of the BOP 604.

[0059] Figure 6B shows a cross section of another embodiment of a fastener 650 in accordance with the invention. The fastener 650 includes a head 651 at the upper end of the elongated shaft 665. The head 651 is retained in a recess 616 of a BOP 604 by a retaining ring 635 that is positioned in a groove 637 in the recess 616. In some embodiments, such as the one shown in Figure 6B, a support washer 643 is included between the retaining ring 635 and the head 651 that strengthens the connection.

[0060] Figure 7A shows a side view of lower BOP 702 and an upper BOP 704 that are coupled according to one embodiment of the invention. The lower BOP 702 includes a lateral passage 712 that leads from the outside of the lower BOP 702 to a recess (shown at 713 in Figure 7B) that is internal to the lower BOP 702. The passage 712 includes a slot 714 that enables the movement of the elongated shaft 726 of the fastener 720.

[0061] The upper BOP also includes a lateral passage 715 that leads from the outside of the upper BOP 704 to a recess (shown at 716 in Figure 7B) that is internal to the upper BOP 704. The passage 715 includes a slot 717 along the lower side of the upper BOP 704 that enables the movement of the elongated shaft 726 of the fastener 720.

[0062] The fastener 720 shown in Figure 7A also includes a nut 731 that is in threaded engagement with a threaded section 723 of the fastener 720. The threaded section 723 is near the opposite end of the elongated shaft 726 from the

head 721. As will be described later with reference to Figure 7B, the nut enable the tightening and loosening of the engagement between the BOPs.

[0063] Figure 7B shows a cross section taken along line A–A in Figure 7A. The fastener 720 includes a head 721 at one end that can be positioned in the recess 716 in the upper BOP 704 by passing it through the lateral passage 715. Element 717 (which is also shown in Figure 7A) of the upper BOP 704 is shown in dashed lines because it is not part of the cross section. It is still shown to illustrate how the head 721 is retained in the recess 716 in the upper BOP 704.

[0064] The nut 731 proximate the second end of the fastener 720 is retained in the recess 713 of the lower BOP 702. Element 714 (also shown in Figure 7A) in the lower BOP 702 is shown in dashed lines to illustrate how the nut 731 is retained in the recess 713 of the lower BOP 702.

[0065] As can be seen in Figure 7B, the fastener 720 may simultaneously be inserted into the recesses 713, 716 in both the lower BOP 702 and the upper BOP 704. Thus, with this embodiment of the invention, the BOPs 702, 704 may be positioned in a BOP stack, and then the fastener 720 may be installed to couple the BOPs 702, 704 to each other.

[0066] The recess 713 in the lower BOP 702 is shaped to match the shape of the nut 731 so that the nut 731 is prevented from rotating relative to the lower BOP 702 when the nut 731 is retained in the recess 713. In some embodiments, the nut 731 has a typical hexagonal bolt shape, although other shapes are also within the scope of the invention.

[0067] The fastener 720 shown in Figure 7B also has a grip section 725 along the elongated shaft 726 of the fastener 720. The grip section 725 is positioned so that it can be accessed in the space between the BOPs 702, 704. The grip section 725 is shaped so that it can be gripped by a wrench or other tool (not shown) and rotated with respect to the BOPs 702, 704. In some embodiments, the grip section

725 has a typical hexagonal bolt shape, although other shapes are also within the scope of the invention.

[0068] When the fastener **720** is rotated with respect to the BOPs **702, 704**, it is also rotated with respect to the nut **731**, which is prevented from rotating with respect to the BOPs **702, 704**. The threaded engagement between the nut **731** and the fastener **720** enables the engagement between the BOPs **702, 704** to be tightened and loosened by the rotation of the fastener **720**, depending on the direction of rotation.

[0069] A fastener in accordance with the invention is not limited to having an integral head. It is noted that a nut is one type of an adjustable head. Thus, “head” is intended to mean a portion of the fastener that is larger than the nominal diameter of the shaft. Such a head may be integral, or it may be coupled to the shaft in any way known in the art, such as with a nut.

[0070] The embodiment shown in Figures 7A and 7B included slotted BOPs with recesses to retain the head or the nut of the fastener. Alternatively, a BOP may include a latch or a pin that holds the fastener in place. Also, the slot in one or both of the BOPs may be sloped so that tightening the connection will prevent the fastener from being removed from the slot of either BOP.

[0071] Figure 8A shows a cross section of a fastener **810** in accordance with another embodiment of the invention. The fastener includes two members **812, 822** that are each coupled to a BOP and that are coupled to each other. The lower member **822** includes a head **821** on one end that is retained in a recess **826** in the lower BOP **802** by a retaining collar **817**. The other end of the first member **822** comprises a threaded member **833** that is coupled to a female section **808** of the second member **812** of the fastener **810**.

[0072] The second fastener **812** includes a head **821** on one end that is retained in a recess **806** in the upper BOP **804** by a second retaining collar **827**. The other end

of the second member **822** is a female threaded section **808** that is coupled to the first member **812**.

[0073] In the embodiment shown, the first member **812** and the second member **822** are coupled by a threaded connection. Thus, rotation of one of the members with respect to the other member will cause the connection to be tightened or loosened, depending on the direction of rotation. In some embodiments, the second member **822** includes a grip section **825** that enables the first member **822** to be gripped by a wrench or other tool (not shown) so that it may be more easily rotated with respect to the second member **812**.

[0074] The recess **806** in the upper BOP **804** is shown extending farther into the upper BOP **804** than the recess **826** in the lower BOP **802**. This enables an upward or downward movement of the second member **822** to facilitate making the connection between the two members **812**, **822** after the BOPs **802**, **804** are positioned in a BOP stack. Additionally, the recess **806** in the upper BOP **804** may be shaped to prevent the rotation of the second member **812** relative to the upper BOP **804**. For example, the head **811** of the second member **822** may be a hexagonally shaped head, like that of a bolt or nut. The recess **806** may also have a similar hexagonal shape that prevents the second member **822** from rotating.

[0075] Figure 8B shows another embodiment of a two-piece fastener **860** in accordance with the invention. The upper member **850** of the fastener includes a head **851** that is retained in a recess **856** in the upper BOP **854**. The embodiment shown in Figure 8B does not include a retaining collar (e.g., **817** in Figure 8A) that retains the head **851** in the recess **856**. Instead, the upper BOP **854** is designed to retain the head **851**. That is, upper member **850** of the fastener **860** is permanently retained in the recess **856**. In some other embodiments, the upper BOP **854** may include slots that enable the head **851** of the upper member **850** to be inserted from outside of the upper BOP **854**.

[0076] The lower member 861 of the fastener 860 includes a first threaded section 864 coupled to the lower BOP 852 and a second threaded section 863 coupled to the upper member 850 of the fastener 860. Rotation of the upper member 850 with respect to the lower member 861 will tighten or loosen the connection, depending on the direction of rotation.

[0077] In the embodiment shown in Figure 8B, the recess 856 in the upper BOP 854 is shaped to enable the rotation of the head 851. The lower member 861 is prevented from rotation by its engagement with the lower BOP 852.

[0078] The upper member 850 includes a grip section 855 that enables the upper member 850 to be gripped by a wrench or other tool (not shown) and rotated. In some embodiments, the grip section 855 is hexagonally shaped.

[0079] It is intended that the scope of the invention includes embodiments of a fastener with various of the features described herein, even though the particular features were not shown on the same embodiment. For example, an embodiment of a fastener in accordance with the invention may include a head on both ends of the fastener (*i.e.*, as shown at 411 in Figure 4A), where each head is retained in a recess of a BOP by a separate retaining collar. Also, a fastener may not include a head where each end of the fastener includes a threaded section that is in threaded engagement with a BOP. Those having skill in the art will be able to devise embodiments of a fastener that include any combination of the features described herein.

[0080] Additionally, many aspects of the present invention are described as including threads or being in threaded connection with another member. Nonetheless, the invention is not intended to be limited to threaded connections. For example, a retaining collar in accordance with the invention may be coupled to a BOP with a tongue and groove connection or with notches that fit into slots where the retaining collar can be rotated so that the notches are locked in place.

While a threaded connection is used in some embodiments because of the ease of coupling the two members together and the strength of the connection, those having ordinary skill in the art will be able to devise other types of connections that do not depart from the scope of the invention.

[0081] Advantageously, the present invention enables two BOPs to be coupled together in a way that minimizes the vertical height of the BOP stack. A BOP fastener in accordance with the present invention provides more space near the well head for other well tools and equipment to be located, and it provides more space in which rig personnel can maneuver. Additionally, a fastener in accordance with one or more embodiments of the invention requires less effort and work to couple two BOPs together.

[0082] The present invention may also be useful in connecting any two pressure containing bodies where space is an important factor. Further, due to the ease of connection, embodiments of the invention may be used where a flange or other means of connection would be difficult, dangerous, or burdensome. For example, embodiments of a fastener may be used to couple two sections of pipe that would otherwise be coupled by a typical flange. Also, a fastener in accordance with one or more embodiments of the invention may be used to connect an access door to a large pressure containing vessel. Advantageously, the access door with such a fastener would require less space and be easy to remove and install.

[0083] While the invention has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the invention as disclosed herein. Accordingly, the scope of the invention should be limited only by the attached claims.